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Pulsed laser deposition (PLD) of the solar cell materials CZTS and CTS

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Background: The world demand of electricity supply at a Tera-Watt scale means that there is a need for earth abundant and non-toxic materials. Therefore, many efforts are currently devoted to exploit the full potential of the absorber layer Cu2ZnSn(S,Se)4 (CZTS), which has a similar structure and similar band-gap as Cu(In,Ga)Se2 and is fully made by earth-abundant materials. The record efficiency of CZTS solar cells has been greatly improved during the last few years, reaching 12.6% with a sulfo-selenide blend and with a 50 nm thick buffer layer of CdS. While these results are very encouraging, Se- and Cd- free solutions are still at an early stage of development. Regarding the pure sulfide Cu2ZnSnS4, the annealing step is very critical for the physical quality of the absorber layer. Many difficulties are related to the high volatility of sulfur and of its binary compounds.

Idea: The idea is to make the annealing process more controllable and reproducible by using a cap layer on top of the CZTS before the annealing. The cap layer should prevent decomposition reactions and assist in self-balancing the stoichiometry. For this purpose we have selected a thin layer of ZnS.

- ZnS can serve as buffer layer.
- ZnS is made of earth abundant material, unlike CdS.
- ZnS withstands high temperatures, so it can be annealed together with the CZTS layer.

We compare the results of annealing the bilayer CZTS/ZnS to the annealing of a single CZTS layer. In the first case, the enhancement in the crystalline quality of both layers is clearly visible from the x-ray diffraction patterns and SEM images.

Experimental technique: We deposit a bilayer of CZTS/ZnS onto Mo-coated Soda Lime Glass by using Pulsed Laser Deposition (PLD). The laser is operating at 248 nm, 10 Hz and 3 J/cm^2. The targets were made of stoichiometric, sintered powder; Depositions were carried out under high vacuum (p ~ $1*10^{-6}$ mbar) and the substrate temperature was fixed at 300^o C. Annealing was done in a tube furnace in a N_2 + S_2 atmosphere at 550^o C for 30 minutes.